Title of Project:
Implementation of Repeated Measures ANOVA Model:
Examining The Effectiveness of Training Nurses to Treat Tobacco Dependency

Data Source, Definitions & Main Features of Data Set:

Introduction to Study

Due to previous collaboration, Dr. Christine Sheffer has given me permission to use a de-identified version of her study's dataset, which will be described below. This study was funded by a Medical Education Grant from Pfizer, Inc. awarded to the University of Arkansas for Medical Sciences.

A one-hour training for healthcare professionals (including students) consisting of an evidence-based treatment for tobacco dependency was conducted in-person or online with N=2120 participants. An assessment was given immediately prior to training (pre), immediately after training (post), and at the 6-month mark after training (follow-up).

In addition to the assessment, a great deal of demographic data for each participant was collected prior to training. Demographic data will be detailed later.

Data Cleaning

Sample size began with N=2120 participants being trained. Of those, N=874 where successfully contacted at the 6-month mark after training. This dataset is referred to as dat_org in the associated R code.

For the purposes of this study and to examine and homogenous sample, the dataset was subsetted to examine only nurses (N=594). A nurse was considered anyone who indicated their professional background as one of the following: RN, BSN, APN, and NP.

A filter was then applied to only include those nurses who had completed every question of the Knowledge & Assessment Domain (KA) at each time point (N=190). This dataset is referring to as dat.nurse in the associated R code. Data was also restructured for analysis: dat.nurse_re

Categorical demographic data was then cleaned to reduce number of categories and to categorize answers that participants had written-in.

Sample Demographics (N=206)

Table 1:

Variable	Statistic	Variable	Statistic
Gender-Female	89.66% (N=182)	Prior Training in Tob. Cessation	18.69% (N=37)
Race		Work Setting	
White	87.50% (N=175)	Academic	75.78% (N=122)
Black/African American	9.00% (N=18)	Private Industry	11.80% (N=19)
Other	3.50% (N=7)	Other	12.42% (N=20)
Age in years	M=39.14 (SD=12.65)	Years Practicing	M=12.40 (SD=11.90)

Tobacco Use Status*	
Never used regularly	73.10% (N=144)
Former user	23.35% (N=56)
Current user	3.55% (N=7)

Contact with Patients-Yes	92.86% (N=65)

Details of Assessment

Assessments included 3 primary domains: General "Knowledge & Attitudes" (regarding tobacco cessation programs), and "The 5 A's" (frequency of participant use of model used treat tobacco dependency), and "Course Assessment" (test over the content of the course). All responses to each question in each domain was on a Likert scale from (0-11) with 0 representing "Not at All" and 11 representing "Most Possible".

For the purposes of this project, we will focus on the Knowledge & Attitudes domain, referred to as KAD for the remainder of this paper. The KAD consisted of 11 questions. Here is a snipbit of the questions from the actual assessment presented to participants:

Please rate each item by **FILLING IN** the circle of the proper number.	**0 = Not at all**										**Most possible = 10**
How knowledgeable are you in performing tobacco cessation interventions?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How motivated are you to help someone stop using tobacco?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How important is tobacco cessation to your work?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How easily can you overcome the barriers you experience when providing tobacco cessation interventions to patients?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How confident are you in your ability to assist patients with tobacco cessation?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How prepared are you to provide tobacco cessation interventions?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How effective are treatments for tobacco use?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How much do you need additional staff and resources to provide tobacco cessation interventions?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How much do you know about obtaining reimbursement for the delivery of tobacco cessation interventions?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How skilled are you in effectively counseling tobacco users?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩
How confident are you that you can address patient motivation to quit?	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩

KAD questions were summed to create a total KAD score. (Note that Question 8 was reverse coded). All following analysis will focus on the KAD total score.

Descriptive Analysis

A basic descriptive analysis was conducted on all levels of the KAD total score. Results suggested a difference between levels of dependent measures. QQ plots where generated for each level and across conditions to access normality (as well as running the Shapiro-Wilk normality test). Results indicated that each level of the condition normality was not technically met (except for the pre score). However, QQ plots suggest that these distributions as not far from normal. In fact, examining Table 2

the “skew” value, we see that the Pre and 6 mo. distributions are approximately symmetrical (value between -.05 and .05 considered exactly symmetrical). The Post distribution is quite negatively skewed, meaning most of the scores fell towards the higher side (See Figure 1 & 2). Contextually, this effect makes sense because participants were just given the training and should have high scores immediately after.

Figure 1: Boxplot of Scores Across Conditions

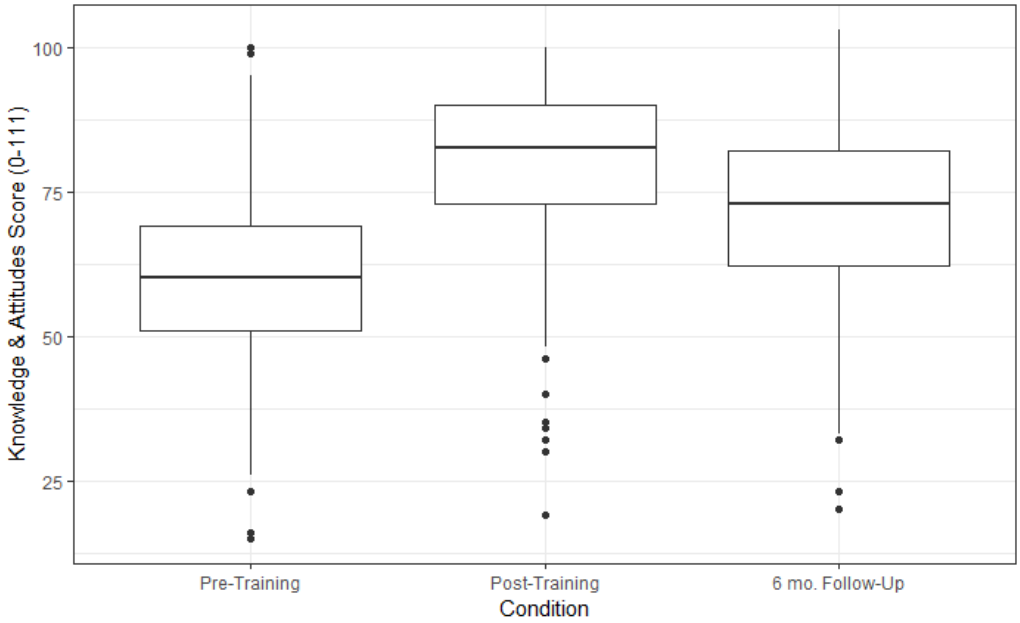
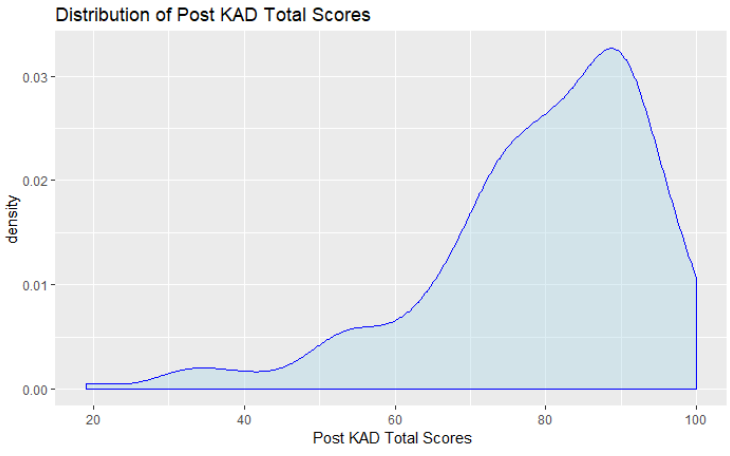


Table 2: Descriptive Statistics Across Conditions

Condition	n	mean	sd	se	median	min	max	range	skew
Pre KAD Score	206	59.61	15.79	1.10	60.00	15	100	85	-0.2270
Post KAD Score	206	79.33	14.92	1.04	82.50	19	100	81	-1.2488
6 mo. KAD Score	206	71.65	14.95	1.04	73.00	20	103	83	-0.5405

Figure 2: Density & QQ Plot of Post Scores



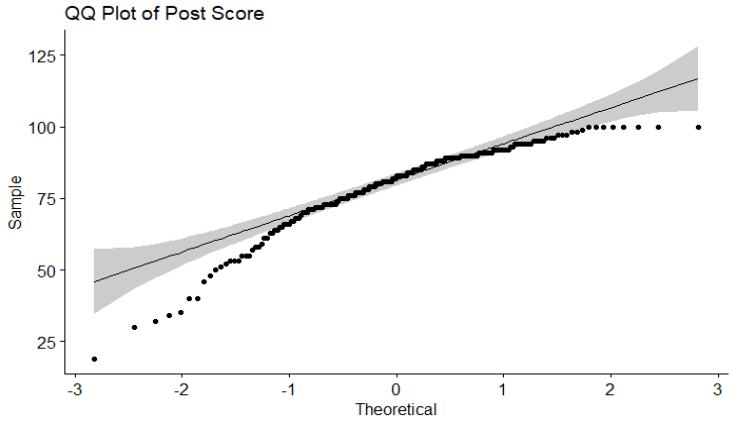
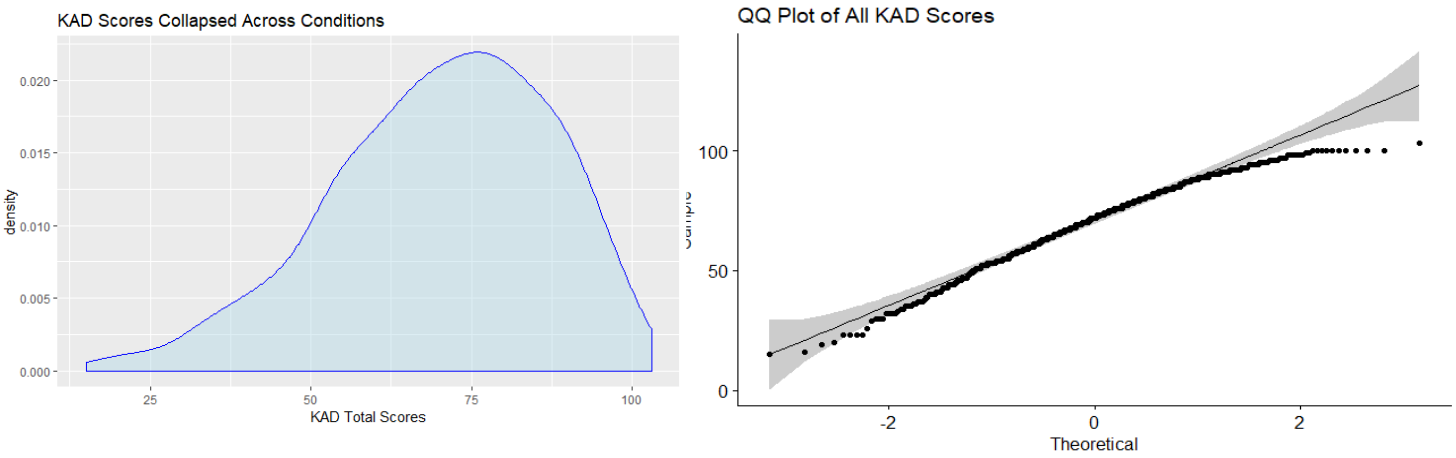


Figure 3: Density & QQ Plot of All Score Collapsed Across Conditions



Research question

Will a 1-hour tobacco cessation training result in systematic changes in knowledge and attitudes on tobacco cessation (as measured by the KAD total score) for nurses in our sample?

Method: Repeated Measures ANOVA

A repeated measure ANOVA the experimental effect of condition is represented by the Within-Participants Variance (referred to as $\mathbf{SS_W}$) as opposed to the typical between-group variance you may be accustomed to seeing in a one-way ANOVA with independent groups.

The value of $\mathbf{SS_W}$ can also be thought of as the sum of $\mathbf{SS_M}$ (Model Sum of Squares) and $\mathbf{SS_R}$ (Error Sum of Squares).

The value of $\mathbf{SS_M}$ is the sum of squares consisting of the difference in the sample mean for each level of the condition and sample grand mean (mean of scores regardless of condition).

In our example we have:

$$SS_M = \sum_{n=1}^{k=3} n_k(\bar{x}_k - \bar{x}_{grand})^2$$ where *k* represents each of the 3 levels of the condition.

The total sum of squares, or $\mathbf{SS_T}$ is the sum of $\mathbf{SS_W}$ and the between-participants sum of squares ($\mathbf{SS}$ $\mathbf{SS_B}$ accounts for the variation in response between each participant.

If calculating by hand, it is easiest to start with the $\mathbf{SS_W}$ and $\mathbf{SS_M}$ calculation. $\mathbf{SS_R}$ can then be easily determined through addition and subtraction. ($\mathbf{SS_R} = \mathbf{SS_W} - \mathbf{SS_M}$)

To calculate the F ratio, $\mathbf{MS_M}$ and $\mathbf{MS_R}$ need to be computed. Each of these values is simply the associated $\mathbf{MS_M}$ divide by the corresponding degrees of freedom.

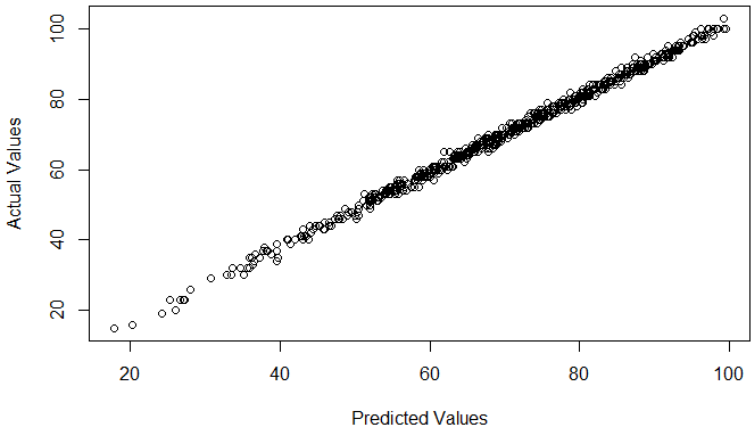
$$F = \frac{MS_M}{MS_R}$$

With the F ratio, we are comparing the size of the experimental effect to the size of the random factors, measured as error. The greater the F ratio, the more confident we can be there was an experimental effect.

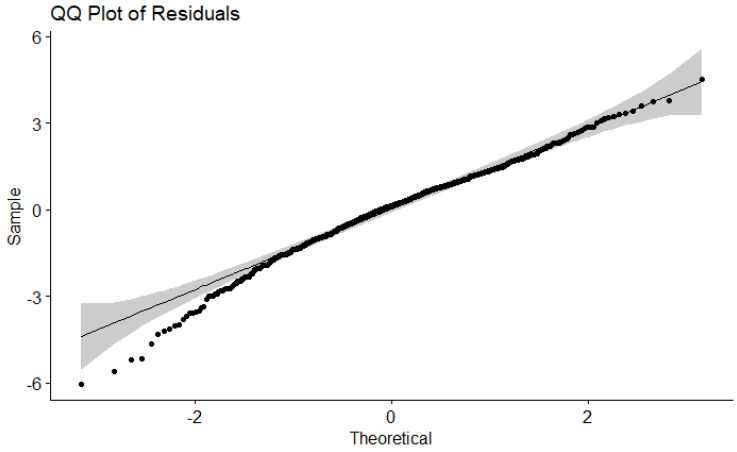
Testing Assumptions of Method

Assumptions of a repeated measures ANOVA include linearity of model, normality of residuals, and sphericity (variances between all possible combinations of levels are equal). Figures below demonstrate that linearity is met, normality of residuals is approximately met, but sphericity is violated. However, we can correct for sphericity so we proceed!

Model Linearity: Figure 4



Normality of Residuals: Figure 5



Sphericity: Figure 6

Mauchly's Test for Sphericity	
Effect	'Condition'
W	0.9469386
p	0.003844379
p<.05	'*'

Application of Method

In order to examine differences on the KAD scores across conditions, a repeated measures ANOVA with one within factor (condition) was conducted.

The repeated measures ANOVA model was chosen based on the fact: the dependent measure is a continuous scale and the grouping variable is within subjects and has more than 2 categories or time points.

While a linear model was constructed using lme to explore assumptions, the package EZ was downloaded and the function ezANOVA was ran to easily obtain values needed for an ANOVA table. The function also includes sphericity corrections, which we need!

Table 3: **ANOVA Results**

Effect	df_m	d_fr	SS_m	SS_r	F	p	GES
Intercept	1	205	3044883	90763	6877	1.16e-159**	0.95
Condition	2	410	40701	51739	161	2.15e-52**	0.22

**p<.01

Table 4: **Greenhouse and Geisser Sphericity Correction**

Effect	GGe	P[GG]
Condition	0.95	6.66 e-50**

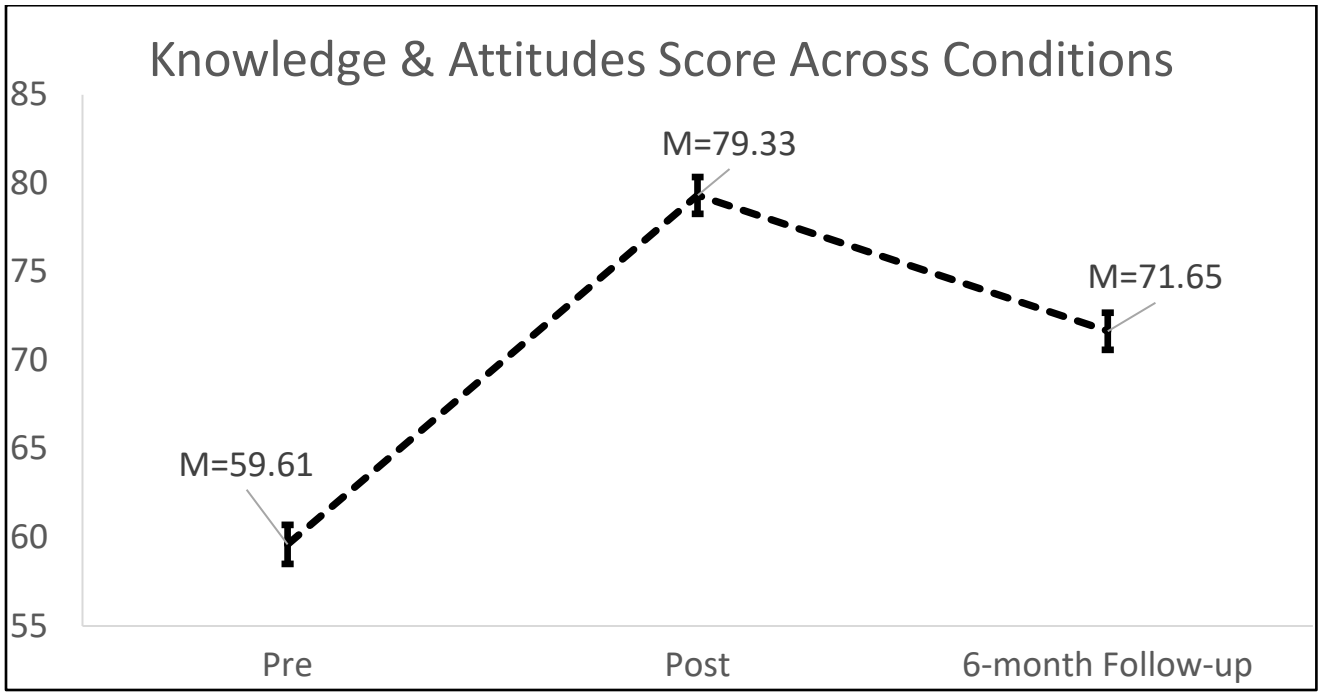
**p<.01

Table 5: **Post Hoc P-Values: Pairwise T-tests with Bonferroni Correction**

Condition	**Pre Score**	**Post Score**
Post Score	2 e-16**	----------
6 mo. Score	1.5 e-14**	1.2 e-06**

**p<.01

Figure 6: **Condition Effect on KAD Total Scores**



Results

Results indicate a significant main effect of condition (pre vs post vs 6 mo.), p=1.16 e-159. With the sphericity correction, we obtain a smaller p-value (p=6.66 e-50) for our condition effect (but it is still significant). Further, each pairwise effect was statistically significant. What is more theoretically important is that at the 6 mo. time period participants scores were still significantly greater than the pre-test scores, p=1.5 e-14.

References

Field, A. P., Miles, J., & Field, Z. (2017). Discovering statistics using R.